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PASTE APPLICATOR

[Abstract]

PURPOSE: To accurately draw a paste pattern by specifically setting the position relation between a nozzle and a base sheet even if the position of the outlet of the nozzle is changed by exchanging the nozzle.

CONSTITUTION: A point P0 is the center of the field of view of a camera and X is the distance from this point P0 to the position directly below the outlet of a nozzle with no positional deviation. Then, a temporary base sheet is arranged so as to be able to photograph it by means of a camera and then, this temporary base sheet is moved by a distance X and a paste

is dropped down on the temporary base sheet from the outlet of the nozzle to apply a dotting paste P1 and in addition, dotting paste P3 and P5 and dotting pastes P2 and P4 are respectively applied at the positions of ±DX and ±DY from the dotting paste P1. Then, the temporary base sheet is moved in the reverse direction of the above described direction by the distance X and the positional deviations of these dottings P1-P5 are detected by using the point P0 as a reference to obtain the amt. of the positional deviation of the outlet on the nozzle. The positional relation between the base sheet on which a pattern is actually formed and the nozzle is adjusted.

[Claim(s)]

[Claim 1] A paste applicator which spreads paste on a substrate in a desired pattern by discharging the paste from a nozzle on the substrate mounted on a table by changing the relative-position between the nozzle and the table comprising:

a measuring means to measure the desired location of the delivery of the nozzle to spread the paste from nozzle at the time of the nozzle replacement at the point of the paste spreading point of an arbitrary number that is in apart from the substrate;

a calculating means to compute location changes of the nozzle delivery by nozzle replacement from the measurement result by the measuring means; and

a positioning means to position this substrate in a desired location to the nozzle delivery after nozzle replacement, from the result obtained with the calculating means.

[Claim 2] The paste applicator of Claim 1, wherein the calculating means calculates the location changes of the nozzle delivery according to the nozzle replacements using either the all statistical measurement result or the statistical measurement result that excludes the first paste spreading point measurement.

[Claim 3] A paste applicator which spreads paste on a substrate in a desired pattern by discharging the paste from a nozzle on the substrate mounted on a table by changing the relative-position between the nozzle and the table comprising:

a measuring means to measure the last paste spreading point of the delivery of the nozzle to spread the paste from nozzle at the time of the nozzle replacement at the point of the paste spreading point of an arbitrary number that is in apart from the substrate;

a calculating means to compute location change of the last nozzle delivery by nozzle replacement from the measurement result by the measuring means; and

a positioning means to position this substrate in a desired location to the nozzle delivery after nozzle replacement, from the result obtained with the calculating means.

[Claim 4] The paste applicator of Claims 1, 2 or 3, wherein the positioning means controls the location of the substrate to a desired location.

[Claim 5] The paste applicator of Claims 1, 2 or 3, wherein the positioning means controls the location of a positioned camera that reads the paste spreading points of arbitrary numbers that are apart from the substrate.

[Claim 6] The paste applicator of Claims 1, 2, or 3 comprising a memory means that can memorize the locations of the nozzle replacements; measuring the location of the nozzle delivery based on information obtained by the memory means; and a positioning means that positions the substrate at a desired location by calculating the location changes of the nozzle delivery after the nozzle replacement.

[Title of the Invention]

A PASTE APPLICATOR

[Detailed Description of the Invention]

[Industrial Applicability]

The present invention relates to a paste applicator for drawing a paste film in a desired pattern on a substrate.

[Description of the Prior Art]

There are known technologies of drawing a paste film in a desired pattern on a substrate by changing the relative positional relationship between a nozzle and the substrate up and down, back and forth, right and left while a paste is being discharged through a nozzle provided at an end of a paste reservoir tube. In a technology disclosed in, for example, Japanese Patent Application Laid-Open No.2-52742, a desired resistive pattern is formed by discharging a resistive paste through a nozzle onto a substrate while the substrate is being relatively moved to the nozzle and the gap between the nozzle and the substrate is being adjusted.

[Problem(s) to be Solved by the Invention]

There are some cases where a paste in a paste reservoir tube is almost discharged by drawing a desired pattern, and lack of the paste occurs halfway through drawing a pattern onto the next substrate. In such a case, refilling a paste into the paste reservoir tube at a midpoint in drawing a pattern causes a structural problem as a precise equipment. Therefore, in such a conventional paste applicator described above, the paste reservoir tube is generally exchanged with a new paste reservoir tube filled with paste before starting drawing of the next substrate. In this occasion, the nozzle is also exchanged because the nozzle is constructed in a one-piece structure with the paste reservoir tube. Hereinafter, such exchange is referred to as "nozzle exchange".

In such a case, the relative position of the nozzle discharging port to the substrate before and after the nozzle exchange is varied due to machining accuracy of the paste reservoir tube or the nozzle and variation of assembling accuracy in the nozzle to the paste reservoir tube. As a result, it has been often difficult to draw a paste pattern starting from a desired position on the substrate.

In a case of drawing, for example, a sealing material in a pattern onto a liquid crystal sealing substrate of a liquid crystal display apparatus, if any positional displacement exists in the pattern of the sealing material, a part of display pixels may be placed outside the pattern of the sealing material and consequently a correct picture cannot be displayed on the screen.

An object of the present invention is to solve the above problem and to provide a paste applicator capable of drawing a paste pattern accurately at a desired position on a substrate even if a positional displacement of a nozzle discharging port to the substrate occurs due to nozzle exchange.

Another object of the present invention is to provide a paste applicator capable of setting the relative positional relationship between the nozzle discharging port and a substrate accurately and automatically when a positional displacement of a nozzle discharging port to the substrate occurs due to nozzle exchange.

[Means for Solving the Problem]

To attain the object described above, the present invention comprises:

a measuring means to measure the desired location of the delivery of the nozzle to spread the paste from nozzle at the time of the nozzle replacement at the point of the paste spreading point of an arbitrary number that is in apart from the substrate;

a calculating means to compute location changes of the nozzle delivery by nozzle replacement from the measurement result by the measuring means; and

a positioning means to position this substrate in a desired location to the nozzle delivery after nozzle replacement, from the result obtained with the calculating means.

The calculating means calculates the location changes of the nozzle delivery according to the nozzle replacements using either the all statistical measurement result or the statistical measurement result that excludes the first paste spreading point measurement.

Furthermore, the present invention characterizes in that it comprising:

a measuring means to measure the last paste spreading point of the delivery of the nozzle to spread the paste from nozzle at the time of the nozzle replacement at the point of the paste spreading point of an arbitrary number that is in apart from the substrate;

a calculating means to compute location change of the last nozzle delivery by nozzle replacement from the measurement result by the measuring means; and

a positioning means to position this substrate in a desired location to the nozzle delivery after nozzle replacement, from the result obtained with the calculating means.

Furthermore, the present invention characterizes in that it comprising:

a memory means that can memorize the locations of the nozzle replacements; measuring the location of the nozzle delivery based on information obtained by the memory means; and a positioning means that positions the substrate at a desired location by calculating the location changes of the nozzle delivery after the nozzle replacement.

At the time when a nozzle is exchanged and the positional displacement of the nozzle discharge port is calculated by applying a very small amount of a paste discharged through a paste discharging port of the nozzle onto a substrate to form a dot-shaped pattern and by reading the position of the dot-shaped paste pattern, the center of the very small amount of the paste discharged through the paste discharging port of the exchanged nozzle seldom agrees with the center of the nozzle discharging port. According to a study conducted by the authors of the present invention, it has been confirmed that by applying a paste on a substrate several times to draw plural dot-shaped patterns separated from one another, the center of the very small amount of the paste discharged through the paste discharging port of the exchanged nozzle gradually comes to agree with the center of the nozzle discharging port.

Based on the above fact, a means for measuring a position of a paste discharging port of a nozzle reads the positions of an arbitrary number of dot-shaped paste patterns separated one another on a substrate, the dot-shaped patterns being formed by the nozzle of a newly exchanged paste reservoir tube filled with the paste. Then, the displacement of the paste discharging port of the exchanged nozzle to a desired position on the substrate is calculated from the measured results measured with respect to the dot-shaped paste patterns. By doing so, an error due to disagreement between the center of the very small amount of the paste discharged through the paste discharging port and the center of the paste discharging port of the nozzle is eliminated, and consequently the positional displacement of the center of the paste discharging port of the nozzle due to the working accuracy or the attaching accuracy of the paste reservoir tube can be determined. Then, by correcting the positional displacement, the paste discharging port of the nozzle to the substrate can be positioned at a desired position and the positional displacement of the nozzle between before and after the nozzle exchange can be eliminated.

The error due to disagreement between the center of the paste pattern and the center of the paste discharging port can be extremely reduced by not using the first data of the dot-shaped patterns. Further, by using the last data of dot-shaped patterns, the displacement of the paste discharging port of the exchanged nozzle can be calculated in a short time using a measured result in which the center of the paste pattern agrees with the center of the paste discharge port of the nozzle without the statistical processing.

At the time when a nozzle is exchanged, the memory means stores information indicating whether the above positional displacement to the new nozzle has been performed or not. By doing so, when a new substrate is mounted, the paste applicator automatically confirms presence or absence of correction of the positional displacement based on the information of the memory means. If it is judged from the information that the correction of the positional displacement has not been performed, the positional relationship between the new nozzle and the substrate is adjusted by determining the positional displacements of the nozzles before and after the nozzle exchange. By performing this operation for each substrate, it is possible to draw a paste pattern starting from the same position on each of the substrates.

[Example]

Hereafter, the example of this invention is explained using a drawing. FIG. 1 is a schematic perspective view showing the overall construction of an embodiment of a paste applicator in accordance with the present invention. Referring to FIG. 1, the structure of the embodiment of a paste applicator in accordance with the present invention includes a nozzle 1, a paste reservoir tube 2 (hereinafter, referred to as "syringe"), an optical displacement meter 3, a Z-axis table 4a, a camera supporting portion 4b, an X-axis table 5, a Y-axis table 6, a substrate 7, a .theta.-axis table portion 8, a base mount 9, a Z-axis table support portion 10, an image recognition camera (substrate positioning camera) 11a, a lens barrel 11b, a nozzle support 12, a substrate attracting table 13, a controller 14, a Z-axis motor 15a, an X-axis motor 15b, a Y-axis motor 15c, a monitor 16, a key board 17, and an external memory 18.

In the figure, the X-axis table 5 is fixed on the base mount 9, and the Y-axis table 6 is mounted on the X-axis table 5 movably in the X-axis direction, and the .theta.-axis table 8 is further mounted on the Y-axis table 6 movably in the Y-axis direction. The substrate attracting table 13 is mounted on the .theta.-axis table 8, and the substrate 7 is attracted to and mounted on the substrate attracting table 13 in such a manner that the four sides of the substrate are parallel to the X-axis and the Y-axis directions respectively.

The X-axis motor 15b and the Y-axis motor 15c are attached to the X-axis table 5 and the Y-axis table 6, respectively. The X-axis motor 15b and the Y-axis motor 15c are controlled and driven by the controller 14 composed of a micro-computer and so on. That is, when the X-axis motor 15b is driven, the Y-axis table 6 and the .theta.-axis table 8 and the substrate attracting table 13 are moved in the X-axis direction, and when the Y-axis motor 15c is driven, the .theta.-axis table 8 and the substrate attracting table 13 are moved in the Y-axis direction. Therefore, by moving the Y-axis table 8 in the X-axis direction and the .theta.-axis table 8 in the Y-axis direction by arbitrary distances using the controller 14, respectively, the substrate 7 can be moved in an arbitrary direction and to an arbitrary position on a plane parallel to the base mount 9. Further, by moving the .theta.-axis table 8 using the controller 14, the substrate 7 can be rotated in the .theta.-axis direction around the Z-axis.

On the surface of the base mount 9, there are mounted the Z-axis table support 10 and the Z-axis table 4a for moving the nozzle support 12 in the Z-direction (vertical directions), the nozzle support 12 connects the nozzle 1 to the syringe 2 and positions the nozzle 1 near lower side of the optical displacement meter 3 serving as a distance meter. In this embodiment, a paste cartridge is composed of the nozzle 1, the syringe 2 and the nozzle support 12 connecting them. Movement of the Z-axis table 4a is performed with the Z-axis motor 15a connected to the Z-axis table 4a which is controlled by the controller 14.

By applying pressure inside the syringe 2 while the Y-axis table 6 and the .theta.-axis table 8 are being driven in the X-axis direction and the Y-axis direction, respectively, a paste is discharged onto the substrate 7 through the paste discharging port of the nozzle 1 to draw a paste pattern on the substrate 7.

Data for instructing a shape of a paste pattern to be drawn on the substrate 7 and data for instructing a desired distance between the paste discharging port of the nozzle 1 and the surface of the substrate 7 are input from the key board 17. The external memory 18 composed of a hard disk drive and so on is for storing various kinds of setting values to be stored in an RAM of a micro-computer in the controller 14 at starting-up the paste applicator.

The image recognizing camera 11a having the lens barrel 11b is attached to the camera support portion 4b to be used for recognizing a position of the substrate 7 at setting an initial position of the substrate 7. Such image data is input to the controller 14 to be used for controlling various parts. The image and the input data from the key board 17 are displayed on the screen of the monitor 16.

FIG. 2 is an enlarged perspective view showing the portion of the syringe 2 shown in FIG. 1. Therein, corresponding parts in the figure to FIG. 1 are indicated by the same reference characters.

In the figure, a triangular cut-portion is formed in the lower end of the optical displacement meter 3, and a light-producing element and a light-receiving element are provided in the cut-portion. A nozzle support 12 extending to the lower portion of the cut-portion of the optical displacement meter 3 is provided in the lower end of the syringe 2, and the nozzle 1 is attached onto the lower surface of the end the nozzle support 12 in such as to position under the cut-portion of the optical displacement meter 3.

The optical displacement meter 3 measures a distance between the top end of the nozzle 1 and the surface of the substrate 7 through a non-contact triangulating method. That is, a laser beam L emitted from a light producing element of the optical displacement meter 3 is reflected at a measuring point S on the substrate 7 and received by the light receiving element of the optical displacement meter 3. In this case, the light producing element and the light receiving element are provided on the different side surfaces of the cut-portion so that the laser beam L is not interrupted by the nozzle support 12, and accordingly the laser beam L is emitted in a slanting direction and reflected in a slanting direction.

Therein, although the measuring point S by the laser beam L and the position right under the nozzle 1 are slightly displaced on the substrate 7 by Δ X and Δ Y, the optical displacement meter 3 can nearly accurately measure the distance between the top end of the nozzle 1 and the surface of the substrate 7 right under the nozzle within such a degree of displacement because there is little difference in the levels of the surface of the substrate 7 between at the measuring point S on the substrate 7 and at the position right under the top end of the nozzle 1.

Even if there is an undulation on the surface of the substrate 7, the controller 14 in FIG. 1 operates the Z-axis table 4a upward and downward based on the measured result of the optical displacement meter 3 during applying a paste onto the substrate. By doing so, the paste discharging port of the nozzle 1 is controlled so as to maintain a desired distance from the surface of the substrate 7, and width and thickness of the applied paste, therefore, become uniform all over the paste pattern.

In order to avoid the measuring point S from crossing over a paste pattern having been already applied on the substrate 7, the measuring point S is set so as to be positioned in a slanting direction with regard to both the X-axis and the Y-axis from a drop point of the paste discharged through the paste discharging port of the nozzle 1.

FIG. 3 is a block diagram showing an embodiment of a controller 14 shown in FIG. 1. The controller 14 includes a micro-computer 14a, an external interface 14e, a motor controller 14b, an X-axis driver 14cb, a Y-axis driver 14cc, a .theta.-axis driver 14cd, a Z-axis driver 14ca, an image processor 14d. The reference character 15d in FIG. 3 shows a .theta.-axis motor, each E shows an encoder and PP shows a paste pattern. Therein, corresponding parts in the figure to FIG. 1 are indicated by the same reference characters.

In the figure, the micro-computer 14a comprises a main processor, a ROM for storing a program of software processing for drawing paste patterns PP to be described later, a RAM for storing a result processed by the main processor and input data from an external interface 14e and a motor controller 14b, and an input/output unit for exchanging data between the external interface 14e and the motor controller 14b.

Inputs to the key board 17 are data to specify a desired shape of a paste pattern to be drawn and data to specify a desired distance between the nozzle 1 and the substrate 7 which are supplied to the micro-computer 14a through the external interface 14e. In the micro-computer 14a, the data is processed according to a software program stored in the ROM using the main processor and the RAM.

According to the data to specify a desired shape of a paste pattern processed in such a manner, the motor controller 14b is controlled, and the X-axis motor 15b, the Y-axis motor 15c or the .theta.-axis motor 15d is driven to be rotated by an X-axis driver 14cb, a Y-axis driver 14cc or a .theta.-axis driver 14cd. Encoders E are provided in the rotating shafts of these motors, and a rotating amount (drive operating amount) of each of the motors is detected to be fed back to the micro-computer 14a through the X-axis driver 14cb, the Y-axis driver 14cc or the .theta.-axis driver 14cd and the motor controller 14b. The micro-computer 14a controls the X-axis motor 15b, the Y-axis motor 15c or the .theta.-axis motor 15d so as to be accurately rotated by the specified amount of rotation. By doing so, the desired paste pattern can be drawn on the substrate 7.

Data measured by the optical displacement meter 3 during drawing a paste pattern is converted to digital data using an A-D converter which is not shown in the figure, and supplied to the micro-computer 14a through the external interface 14e to perform comparing processing with the aforementioned data specifying the distance between the nozzle 1 and the substrate 7. When an undulation exists on the surface of the substrate 7, the microcomputer 14a detects the undulation based on input data and controls the motor controller 14b to drive and rotate the Z-axis motor 15a by the Z-axis driver 14ca. Thus, the Z-axis table 4a (FIG. 1) is moved vertically so as to maintain the distance between the paste discharging port of the nozzle 1 (FIG. 2) and the surface of the substrate 7 constant. An encoder E is also provided in the Z-axis motor 15a, and the detected rotating amount of the Z-axis motor 15a is fed back to the micro-computer 14a. Therefore, the micro-computer 14a controls the Z-axis motor 15a so as to be accurately rotated by the specified amount of rotation.

The build-in RAM of the micro-computer 14a stores data for paste drawing patterns, data at exchanging the paste reservoir tube, various kinds of data input from the key board 17 and various data processed and produced by the micro-computer 14a.

Operation of application of paste for drawing patterns and exchange of the paste reservoir tube will be described below.

In FIG. 4, power is switched on (Step 100), and initialization of the applicator is executed (Step 200).

The initialization is executed in a process as shown in FIG. 5. That is, initially the Z-axis table 4a, the X-axis table 5 and the Y-axis table 6 are positioned at positions of the given origins (Step 201), and then paste film pattern data, substrate position data and paste discharge completion position data are set (Steps 202, 203). The data for setting is input from the key board 17 of FIG. 1. The input data is stored in the build-in RAM of the micro-computer 14a in the controller 14, as described above.

Referring to FIG. 4, it is confirmed and judged whether exchange of the syringe 2 (nozzle exchange) has been executed or not (Step 300) (The exchange of the syringe 2 will be described in paste film forming process (Step 700) of FIG. 10 in detail). If the exchange of syringe 2 has been executed, displacement of the nozzle position is measured (Step 400) and a substrate is mounted (Step 500). If the exchange of the syringe 2 has not executed, a substrate is mounted (Step 500).

Here, the nozzle position displacement process (Step 400) when exchange of syringe has been executed will be described in detail below, referring to FIG. 1 and FIG. 6.

Initially, a temporary substrate is mounted on the substrate attracting table 13 of FIG. 1 (Step 401) and attracted to be held to the substrate attracting table 13 (Step 402), and the temporary substrate is moved so that a portion of the temporary substrate right under the center of a view of the image recognizing camera 11a comes to the position right under the nozzle 1 (Step 403). Then, the nozzle 1 is moved downward using the Z-axis table 4a (Step 404), and dot-drawing is executed by applying a paste filled in the syringe 2 onto the temporary substrate to form a dot-shaped film (Step 405). After that, the nozzle 1 is moved upward (Step 406). The series of the operations from Step 404 to Step 406 are repeated by a pre-set number times.

When it is confirmed that the dot-drawing has been repeated by the preset number times (Step 407), the temporary substrate is moved to a position right under the view center of the image recognizing camera 11a (Step 408). Then, the position of the dot-shaped paste is measured using the image recognizing camera 11a (Step 409). The position measurement is executed in each operation of drawing dot-shaped pattern for all of the dot-shaped paste patterns (Step 410) and the measured data is stored in the RAM in the micro-computer 14a.

FIG. 7 is a diagram explaining the process of the applying dot-shaped paste patterns described above, and shows a feature on the temporary substrate seeing with the image recognizing camera 11a. Therein, the number of forming dot-shaped patterns is five, and these dot-shaped paste patterns are shown by P1 to P5.

In FIG. 1, FIG. 6 and FIG. 7, the operation of drawing dot-shaped paste patterns P1 to P5 is executed by applying the paste on the temporary substrate in arranging the dot-shaped paste pattern P1 in the center and the others equally spaced from the dot-shaped paste pattern P1 by DX and DY in the X-axis and the Y-axis directions so as to not overlap with one another by moving the Y-axis table 6 in the X-axis direction and the .theta.-axis table 8 in the Y-axis direction (Step 405). The frame G shown by dotted line indicates the view of the image recognizing camera 11a, and the distances DX and DY are selected so that all the dot-shaped paste patterns P1 to P5 come within the view G.

Distance X in FIG. 7 indicates a moving distance of the Y-axis table 6 in the X-axis direction from the view center P0 of the image recognizing camera 11a before starting of moving in Step 408. The moving distance X is a pre-determined distance from the view center P0 to a position right under the top end of the nozzle without displacement. Therefore, when the Y-axis table 6 is moved by the distance X, the center of the first applied dot-shaped paste pattern P1 must agree with the center of the view G of the image recognizing camera 11a. Further, the distances between the centers of the dot-shaped paste patterns P2 to P5 and the center of the first applied dot-shaped paste pattern P1 must be DX and DY. However, actually, the distances are displaced.

The displacement contains working accuracy of the paste reservoir tube 2 and the nozzle 1, the deviation in the assembling accuracy of the paste reservoir tube 2 and the nozzle 1 and the disagreement between the center of the nozzle and the center of the small amount of the paste discharged from the paste discharging port of the nozzle at the time when the nozzle is exchanged. One of the causes of the disagreement comes from cleaning at the time when the nozzle is exchanged. If the paste discharging port of the nozzle is carefully cleaned, it takes an unnecessarily long time to exchange the nozzle and workability is degraded. This embodiment is to solve the displacement due to the latter cause by the method to be described as follows.

Each picture of the dot-shaped paste patterns P1 to P5 is taken by the image recognizing camera 11a, and the image data is executed by well-known image processing using the image processor 14d (FIG. 3) to determine the center of gravity of each of the dot-shaped paste patterns, that is, the position of the center of the dot-shaped paste patterns P1 to P5.

FIGS. 8(a) to (e) show image processed results of the positions of the center of the dot-shaped paste patterns P1 to P5. Therein, the solid lines indicate contours of the image-processed dot-shaped paste patterns P1 to P5.

Since the picture of the dot-shaped paste patterns P1 to P5 and the picture of the nozzle cannot be taken at a time using the image recognizing camera 11a, the contour of the nozzle 1 is virtually indicated by a dash-dot line in comparing to the dot-shaped paste patterns P1 to P5. $\Delta X1$ to $\Delta X5$, $\Delta Y1$ to $\Delta Y5$ indicate displacements between the center of the dot-shaped paste patterns P1 to P5 and the center of the nozzle 1 including the displacement due to variation of work accuracy in the paste discharge tube 2 and the nozzle 1 and assembling accuracy of the paste discharge tube 2 and the nozzle 1. The figure shows that as the number of applying the paste increases, the displacement $\Delta X1$, $\Delta Y1$ gradually decreases to $\Delta X2$, $\Delta Y2, \ldots,$ $\Delta X5$, $\Delta Y5$.

Next, an amount of displacement (deviation) between the nozzle 1 and the center of the view G is calculated using the following equations. The deviation is stored in the RAM of the micro-computer 14a as the amount of displacement of the nozzle since the deviation is to be used later (Step 411).

[Equation 1]

$$X mean = \frac{\sum_{i=1}^{n} \Delta X i}{n}$$

[Equation 2]

$$Y_{mean} = \frac{\sum_{i=1}^{n} \Delta Y_i}{n}$$

Where i is number of applying order of the dot-shaped paste patterns P1 to P5, and mean indicates a mean value (averaged value).

Finally, the temporary substrate is released from attracting (Step 412) and thus the nozzle displacement measurement process (Step 400) is completed.

Although the number n of applying order of the dot-shaped paste patterns in this embodiment is 5 and the error comes to smaller value when the number n of applying order of the dot-shaped paste patterns is larger, the number n of applying order of the dot-shaped paste patterns may be arbitrarily set in taking the processing time required for the series of operations of Step 404 to Step 411 into consideration.

Referring to FIG. 4, in Step 500, a substrate 7, on which paste is to be applied for drawing a desired pattern thereon, is mounted on and attracted to the substrate attracting table 13 (FIG. 1), and substrate pre-positioning process is performed (Step 600).

FIG. 9 is a flow chart showing an embodiment of the substrate pre-positioning process in Step 600.

In the figure, initially, picture of a mark for positioning the substrate 7 mounted on the substrate attracting table 13 is taken by the image recognizing camera 11a (Step 601), and the position of the center of gravity of the mark for positioning the substrate within the view of the image recognizing camera 11a is determined through image processing (Step 602). Then, the displacement between the center of view and the center of gravity is calculated (Step 603), and in order to set the substrate 7 to a desired position for starting application, moving amount of the Y-axis table 6 in the X-axis direction, moving amount of the eaxis table 8 in the Y-axis direction and moving amount of the .theta.-axis table 8 in the .theta.-axis direction are calculated using the displacement (Step 604), and further, these amounts are converted to operating amounts of the servo-motors 15b to 15d, 15a using the motor controller 14b (FIG. 3) (Step 605), and then the substrate 7 is set to the desired position by moving the tables 6, 8 in the X-axis and Y-axis directions and the .theta.-direction (Step 606).

In order to confirm that the substrate 7 is set to the desired position, the mark for positioning the substrate 7 is again taken by the image recognizing camera 11a and the center (center of gravity) of the mark for positioning within the view is measured (Step 607), and the displacement of the center of the mark within the view is obtained (Step 608) to judge whether or not the displacement is within an allowable range (Step 609). If the displacement is within the allowable range, the substrate pre-positioning process (Step 600) is completed. If not, the processing is returned to Step 604 and the above process is repeated.

When the substrate pre-positioning process (Step 600) is completed, the processing proceeds to the paste film formation process in FIG. 4 (Step 700).

FIG. 10 is a flow chart showing an embodiment of the paste film formation process.

In the figure, initially, the substrate 7 is moved to a starting position of application (Step 701) and comparison and adjusting movement of the substrate is performed (Step 702). This process is based on the displacement measurement process (Step 400) for the nozzle 1 described above, as shown in FIG. 6 and FIG. 7. The process will be described below, referring to FIG. 11.

Initially, it is judged whether or not the amounts of positional displacement Xmean, Ymean of the nozzle 1 (FIG. 1) determined in Step 409 of FIG. 6 and stored in the RAM of the micro-computer 14a (FIG. 3) are within an allowable range △X, △Y (Step 702a). If the amounts of displacement are within the allowable range △X□Xmean, △Y□Ymean), the processing directly proceeds to the next process in FIG. 10, that is, the nozzle level setting process (Step 703).

If the amounts of displacement exceed the allowable range $\Delta X<Xmean$, $\Delta Y<Ymean$), in FIG. 11, moving amounts of the Y-axis and the .theta.-axis tables 6, 8 in the X-axis and Y-axis directions are calculated from the aforementioned positional displacements Xmean and Ymean (Step 702b), and operating amounts are input to the motor controller 14b (FIG. 3) (Step 702c). Then, the servo-motors 15b, 15c are rotated through the X-axis and the Y-axis drivers 14cb, 14cc by specified amounts, respectively, and the Y-axis and the .theta.-axis tables 6, 8 are moved in the X-axis and the Y-axis directions to set the substrate 7 at the desired position by eliminating the displacement between the paste discharging port of the nozzle 1 and the desired position on the substrate 7 which is caused by exchanging the nozzle 1 (Step 702d). Thus, the process of Step 702 in FIG. 10 is completed.

In FIG. 10, after completion of process Step 702, the level of the nozzle 1 is set (Step 703). Therein, the gap between the paste discharging port of the nozzle 1 and the surface of the substrate becomes the thickness of applied paste. Since the substrate 7 is set at the desired position by the substrate pre-positioning process (Step 600) in FIG. 9 and the substrate position comparison and adjusting movement process in FIG. 11 (Step 702) as described above, after completion of setting the level of the nozzle 1, the paste is discharged to start the operation of drawing (Step 704).

At the same time, undulation of the surface of the substrate 7 is measured using measured data output from the optical displacement meter 3 (Step 705), and it is judged from the measured data of the optical displacement meter 3 whether the measuring point S (FIG. 2) of the optical displacement meter 3 is on a paste film or not (Step 706). Since the measuring data of the optical displacement meter 3 abruptly changes to an allowable value when the measuring point S of the optical displacement meter 3 passes across a paste film, this judgement is performed by detecting that the measured data from the optical displacement meter 3 abruptly changes to exceed the allowable value.

When the measuring point S of the optical displacement meter 3 is not on a paste film, correcting data for moving the Z-axis table 4a corresponding to undulation of the surface of the substrate 7 is calculated based on the measured data (Step 707). Level of the nozzle 1 is corrected using the Z-axis table 4a to maintain the position of the nozzle 1 in the Z-axis direction at a preset value (Step 708).

When it is judged that the measuring point S of the optical displacement meter 3 passes across a paste film (Step 706), the paste is discharged to form the film while the level of the nozzle 1 is not changed and held as it is. This is because since in most cases there is no change on the surface of the substrate 7 while the measuring point S of the optical displacement meter 3 passes across a very small width of a paste film, there is no change in shape of the discharged paste and,therefore, a desired paste film can be drawn if the level of the nozzle 1 is not changed. When it is measured that the measuring point S has passed through the paste film, the processing is returned to the original process of nozzle level correction.

The drawing operation is further progressed, it is judged whether the paste discharging is completed or not based on whether the preset pattern operation is completed or not (Steps 709, 710). The judgement of whether the paste film forming is completed or not is executed by whether the substrate 7 reaches to a position corresponding to a final terminal end of the preset pattern (Step 711). If the substrate 7 does not reach to a position corresponding to a final terminal end yet, the series of the above processes from Step 705 are repeated. In such a manner, the paste film forming is continued until the paste film forming reaches to the final terminal end of the pattern. When the paste film forming reaches to the final terminal end of the pattern, the nozzle 1 is moved upward (Step 712) by driving the Z-axis table 4a to complete the paste film forming process (Step 700).

After completion of the paste film forming process, in FIG. 4, the substrate 7, on which the paste drawing is completed, is unloaded from the substrate attracting table 13 (Step 800), and it is judged whether the whole process is stopped or not (Step 900). That is, when the same pattern of the paste film is formed on a plurality of substrates, the series of the operation from the syringe exchange judging process (Step 300) to the substrate unloading process (Step 800) is repeated as many times as the number of the substrates.

In stop judging process (Step 900), whether or not the paste in the paste reservoir tube (syringe) 2 remains sufficiently is judged through, for example, confirmation of an operator or judgement of the micro-computer 14a using accumulated amount of discharged paste after exchange of the nozzle. If the remaining paste is little, the syringe 2 is changed at that time, and information that the nozzle has been exchanged is input from the key board 17 and the information, for example, a flag is stored in the RAM in the micro-computer 14a. By doing so, when the syringe exchange judgement process (Step 300) is executed after that time, the processing can automatically proceed to the next step of the nozzle displacement measurement process (Step 400) by confirming presence or absence of the flag in a data table with regard to syringe exchange in the RAM.

After confirming presence or absence of the flag in a data table with regard to syringe exchange in the RAM and automatically proceeding to the next step of the nozzle displacement measurement process (Step 400) to measure a displacement, the flag is eliminated. Therefore, the nozzle displacement measurement process (Step 400) is not executed unnecessary until the next nozzle exchange is performed.

In a case where shortage of the paste in the syringe 2 occurs in the midway of the paste film formation process (Step 700) in FIG. 10 and the nozzle is changed, if there is no obstacle in that the processing proceeds to the substrate unloading process (Step 800) at that time or the paste application onto the substrate is continued just as it is without nozzle exchange, the syringe exchange judgement process (Step 300) and the nozzle displacement measurement process (Step 400) in FIG. 4 may be performed before re-started of the paste film formation process (Step 700).

In FIG. 11, when the amounts of positional displacement of the nozzle 1 Xmean and Ymean exceed the displacement allowable range Δ X, Δ Y of the nozzle 1 shown in FIG. 2, the substrate 7 is moved. However, the camera support portion 4a may be constructed so as to move and adjust in the X-axis and the Y-axis directions to the Z-axis table support portion 10 and the amounts of positional displacement of the nozzle 1 Xmean and Ymean may be brought within the displacement allowable range Δ X, Δ Y by moving the image recognizing camera 11a instead of moving the substrate 7.

Since the data Δ X1, Δ Y1 for the first dot-shaped paste pattern described in FIG. 7 and FIG. 8 includes a large error, the amounts of positional displacement of the nozzle 1 Xmean and Ymean in Step 411 of FIG. 6 may be calculated based on the data Δ X2, Δ Y2 and the following without using the data Δ X1, Δ Y1 for the first dot-shaped paste pattern. Further, the displacement Δ Xi, Δ Yi for each of the dot-shaped paste patterns converges to the last dot-shaped paste pattern, as described above, the data Δ Xn, Δ Yn for the last dot-shaped paste pattern may be used for the amounts of positional displacement of the nozzle 1 instead of using the result of the statistical process (averaging process).

Further, in order to shorten the required time for the applicator initialization process (Step 200) in FIG. 4, by connecting a memory read-out device for an IC card or the external memory means 18 (FIG. 3) such as floppy disk, hard disk or the like to the external interface 14e (FIG. 3) and by performing setting of the various kinds of data required for the applicator initialization process using a personal computer or the like in advance, the data may be transmitted by off-line from the external memory means 18 to the RAM of the micro-computer 14a (FIG. 3) through the memory read-out device connected to the external interface 14e at applicator initialization period.

The modified embodiments described above may be arbitrarily combined.

[Effect of the Invention]

As described above, according to the present invention, even when a position of the paste discharge port of a nozzle to a substrate is changed due to nozzle exchange, a paste pattern can be accurately drawn by positioning the nozzle and pattern can be accurately drawn by positioning the nozzle and the substrate in a desired positional relationship.

[BRIEF DESCRIPTION OF THE DRAWINGS]

FIG. 1 is a schematic perspective view showing the overall construction of an embodiment of a paste applicator in accordance with the present invention.

FIG. 2 is a perspective view showing the relationship between a paste reservoir tube and an optical displacement meter shown in FIG. 1.

FIG. 3 is a block diagram showing an embodiment of a controller shown in FIG. 1.

FIG. 4 is a flow chart showing the operation of applying paste in the embodiment of FIG. 1.

FIG. 5 is a flow chart showing an embodiment of application initializing process in FIG. 4.

FIG. 6 is a flow chart showing an embodiment of nozzle displacement measuring process in FIG. 4.

FIG. 7 is a diagram explaining the process of tentatively applying dot-shaped paste patterns on a substrate in FIG. 6.

FIG. 8 is a diagram showing the method of determining a positional displacement of a nozzle in FIG. 6.

FIG. 9 is a flow chart showing an embodiment of substrate pre-positioning process in FIG. 4.

FIG. 10 is a flow chart showing an embodiment of paste film forming process in FIG. 4.

FIG. 11 is a flow chart showing an embodiment of substrate position comparison and adjusting movement process in FIG. 10.

(Description of the Reference Numerals in the Drawings)

1 Nozzle

2 Paste Reservoir Tube

3 Optical Displacement Meter

4a Z-axis table

4b Camera support portion

5 X-axis Table

6 Y-axis Table

7 Substrate

8 Theta Shaft Table

9 Base Mount

10 Z-axis Table Support portion

11a Image recognition camera

11b Lens-barrel

12 Nozzle Support

13 Substrate attracting table

14 Controller

15a-15d Servo motor

16 Monitor

17 Keyboard

18 External Memory